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INDUSTRIAL WASTE SURVEY REPORT ON SUGAR BEET FACTORY WASTES, BUCKEYE SUGAR COMPANY, OTTAWA, OHIO, NOVEMBER 20, 1949 TO NOVEMBER 27, 1949

Irwin P. Sander, et al

Environmental Health Center
Cincinnati, Ohio

1950

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INDUSTRIAL WASTE SURVEY REPORT

SUGAR BEET FACTORY WASTES

BUCKEYE SUGAR COMPANY

OTTAWA, OHIO

November 20, 1949 to November 27, 1949

An Evaluation of the Reuse of Lattery Wash Water and Pulp Press Water After Treatment with Chlorine

By

Irwin R. Bamler
Assistant Sanitary Engineer

Paul Aguano
Sanitary Engineer (R)

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ABSTRACT

The beet sugar industry is seasonal. Extraction of the sugar from the beet is started in early October, as soon as the first beets are harvested, and the campaign will extend from 1.5 to 3 months, depending on the size of the crop.

At the Buckeye Sugar Company during the 1949 season, beets were floated via the flumes into the factory where they were sliced into V-shaped ribbons called cossettes. The cossettes were placed in cells in the diffusion battery and the sugar extracted. The spent pulp was pressed, dried and sold for animal feed. The thin diffusion juice was purified by carbonation and after the precipitated calcium carbonate (lime waste) was removed by filter presses, it was evaporated to a thick juice and finally crystallized in vacuum pans. Wastes from the beet sugar straighthouse consist of flume waste water, process waste water (battery wash and pulp press water), condenser water and lime waste. These wastes vary considerably in volume and pollutional characteristics.

By use of a closed system in which the process waste water was chlorinated, settled, and reused as diffusion battery water the Buckeye Sugar Company succeeded in eliminating this waste. Chlorine requirements were higher than had been anticipated but this may have been due to the method used to test for chlorine residuals. The amount of sugar extracted from the beet was not affected by the use of this chlorinated water even though it had a relatively high solids and sugar content.

The flume waste water at the above mentioned company was practically eliminated by the use of a closed system. Some spillage, from the flume water receiving well to the river, occurred during the survey but this may have been

due to the abnormal conditions at the time of the survey as the flumes were being cleaned out prior to closing the plant at the end of the campaign. Plant officials have expressed their intention of enlarging the flume water receiving well and when this is accomplished the only waste that will go to the river will be the cooled condenser water which had a population equivalent of 4.8 per ton of beets sliced per day. At the time of the survey the waste discharging to the river had a population equivalent of 25 per ton of beets sliced. Sludge from the flume water sedimentation tank was lagooned and the water lost with the lagooned sludge was made up by the water from the beet washer. Lime waste was lagooned.

Comparison of Wastes

Waste	Buckeye Sugar Company 1949 Operations	Normal Operations (1)
	Sewered Population Equivalents per Ton of Beets per day	
Flume Water	20.2 (2)	22
Process Water	0	40
Lime Drainage	Lagoon	4
Condenser Water	4.8	- (3)
Total	25	66

(1) Eldridge, E.F., Industrial Waste Treatment, p.90, McGraw-Hill-1942

(2) Will be eliminated when flume water receiving well is enlarged

(3) Added in with flume water

GENERAL INFORMATION

1. Organization of Survey

This survey was conducted by the U. S. Public Health Service in cooperation with the Buckeye Sugar Company, Ottawa, Ohio. A conference was arranged on November 14, 1949 by Mr. Bruce M. McDill, Sanitary Engineer, Ohio Department of Health, to acquaint the representatives of the Environmental Health Center with chlorination and reuse of process water as practiced by the Buckeye Sugar Company. Clearance to undertake this survey was obtained from Massachusetts Institute of Technology. This institution holds patent rights on the method of chlorination and reuse of process water in beet sugar manufacture.

2. Date of Survey

November 20-27, 1949

3. Personnel Participating in Survey and Conferences

Buckeye Sugar Company

Ralph Dush, Manager

George Fleming, Plant Superintendent

U. S. Public Health Service

H. M. Black, Senior Sanitary Engineer

R. C. Palange, Sanitary Engineer

P. Agvano, Sanitary Engineer (R)

I. P. Sander, Assistant Sanitary Engineer

W. W. Walker, Chemist

Ohio Department of Health

Bruce M. McDill, Sanitary Engineer

4. Purpose

The survey was conducted primarily to evaluate the method of

chlorination and reuse of process water as practiced by the Buckeye Sugar Company. Chlorination and the reuse of diffusion battery waste water was developed at the Buckeye Sugar Company plant by Dr. E. A. Pearson, who used the process as the subject for a thesis for his doctorate degree from Massachusetts Institute of Technology.

Studies were also made of the flume water system, condenser water, and plant outfall sewer as related to the pollution load discharged to the receiving stream.

5. Location of Plant

The plant is located on the Blanchard River at the south city limits of the Village of Ottawa, Ohio.

6. Raw Materials

Sugar beets grown locally, limestone and sulfur.

7. Production

The average daily tonnage of beets sliced, output of sugar and by-products from this plant for the campaign just completed were reported as follows:

Tons of beets sliced	1000 Tons
Sugar	126.35 Tons (2527-100# sacks)
Molasses	52.62 Tons
Beet Pulp (8% moisture)	52.77 Tons (1055——100# sacks)

8. Operations

The Ottawa plant of the Buckeye Sugar Company produces sugar from beets. Operations were on a three shift (7:00 A.M., 3:00 P.M., 11:00 P.M.) basis during the campaign which this year was approximately 55 days, starting on

October 4 and extending through November 27.

The plant has a rated slicing capacity of 1000 tons of beets per day and during this campaign operated at rated capacity, slicing 54,900 tons of beets in 54.88 days. During the past campaign the plant was operated as a straight house although facilities are available to operate a Steffen's house.

9. Employees

There were two hundred forty five employees at the plant over the three shifts. Two hundred and forty (80 per shift) of these were operating personnel while the remainder were administrative personnel.

10. Water Supply

Water from the Blanchard River was used for practically all processing operations. Buckeye Sugar Company officials estimated, on basis of outfall sewer flow and other consumptive uses in the plant, that the total pumpage from the river was approximately 3,500,000 gallons daily. No metering of this supply was attempted at the plant. Figure 1 is a flow diagram showing water utilization in the plant.

Well water from the Village of Ottawa is used for drinking and sanitary purposes, and for sugar wash in the centrifuges. The consumption from this source averaged 19,000 gallons per day.

11. Sewers

The single outfall sewer of the plant discharges to the Blanchard River about 200 yards below the plant water intake. The sewer carried cooled condenser water, overflow from the flume water system, floor drainage and sanitary sewage. Company officials have no plat plan of waste lines and it was therefore impossible to determine if any unauthorized wastes were enter-

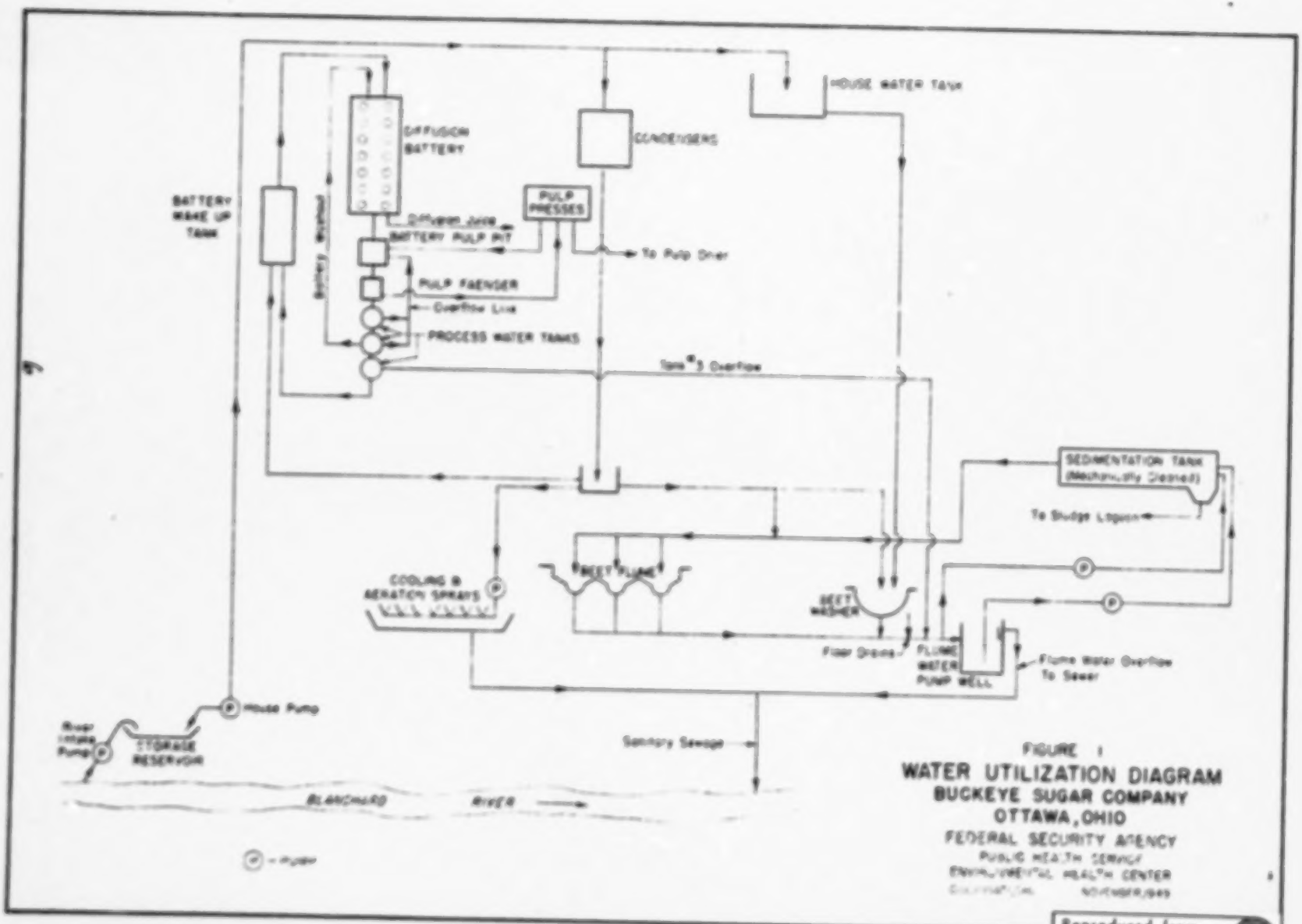

FIGURE 1

WATER UTILIZATION DIAGRAM
BUCKEYE SUGAR COMPANY
OTTAWA, OHIO

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CINCINNATI, OHIO NOVEMBER 1949

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ing the sewer.

DESCRIPTION OF PROCESS

12. Manufacturing Operations

Sugar beets from the stockpile are floated into the plant where they are washed, picked over, weighed, and sliced into V-shaped ribbons called "cossettes." The cossettes are then fed into the diffusion battery consisting of 14 bottom dump cells. At the rated capacity of 1,000 tons of beets sliced per day, a cell is charged every 4.3 minutes. Hot water at 55°C. is passed through the cells and the sugar is extracted from the cossettes. Chlorinated process water is introduced into the cell that has the most nearly exhausted cossettes and passes progressively through the battery to the cell containing fresh cossettes, where it is drawn off as diffusion juice. Through this countercurrent flow, the water with the lowest sugar content comes in contact with the cossettes with the lowest sugar content and serves to remove the greatest amount of sugar possible from the beet. After all the sugar has been extracted from the cossettes, they are dumped to the battery pulp pit and are pumped to the fresnager. The screened pulp is pressed and then dried in rotary driers to produce a high grade animal feed. The filtrate from the fresnger enters the first process water tank.

The diffusion juice then enters the first carbonation tank where milk of lime is added followed by the addition of carbon dioxide. The combination of lime and carbon dioxide forms calcium carbonate, an insoluble precipitate, which removes the impurities from the diffusion juice. The mixture is then filtered through filter presses to obtain the first press juice.

The juice then goes to a second carbonation tank where carbon dioxide is again added to precipitate any of the lime remaining in the press juice. It is then filtered and sulfur dioxide is added to the filtered juice to filter

it and adjust its pH and alkalinity. After the addition of sulfur dioxide, the juice is filtered a third time and goes to evaporators where a heavy syrup containing 50-60% sugar is produced. The lime cake left on the filter presses is washed, refiltered on Oliver filters, diluted to a slurry and pumped to a lagoon. The thick syrup goes to melters and filters and finally to vacuum pans where it is boiled until crystals of the desired size are formed. When crystallization is completed the mixture is centrifuged, the crystals remaining in the basket of the centrifuge while the syrup is returned to the pans for boiling and the formation of more crystals. The crystallized sugar is washed with hot water while still in the centrifuge basket to remove any remaining traces of syrup. It is then scraped from the centrifuge and goes to the granulators to be dried prior to packaging. Figure 2 is a flow sheet of the process at the Buckeye Sugar Company.

13. Fluming Water

The sugar beets delivered to the plant were stockpiled over the flumes. As required they were dumped into the flume and floated to the plant where they were washed, picked over, and raised by an elevator to a hopper where they were weighed.

The flume water that was used to transport the beets to the plant was recirculated in a virtually closed system. The build-up of solids in the flume water was controlled by passing the water through a clarification tank installed in the system. Figure 3 is a flow diagram of this system. As shown, there are two points that water can leave the system. A continuous loss occurs from the clarifier with the sludge pumped to the lagoon, while an intermittent loss can occur in the flume water pump well. When water in excess of the capacity of the flume water pump entered the receiving well, an overflow occurred to the plant outfall sewer. Condenser water was used

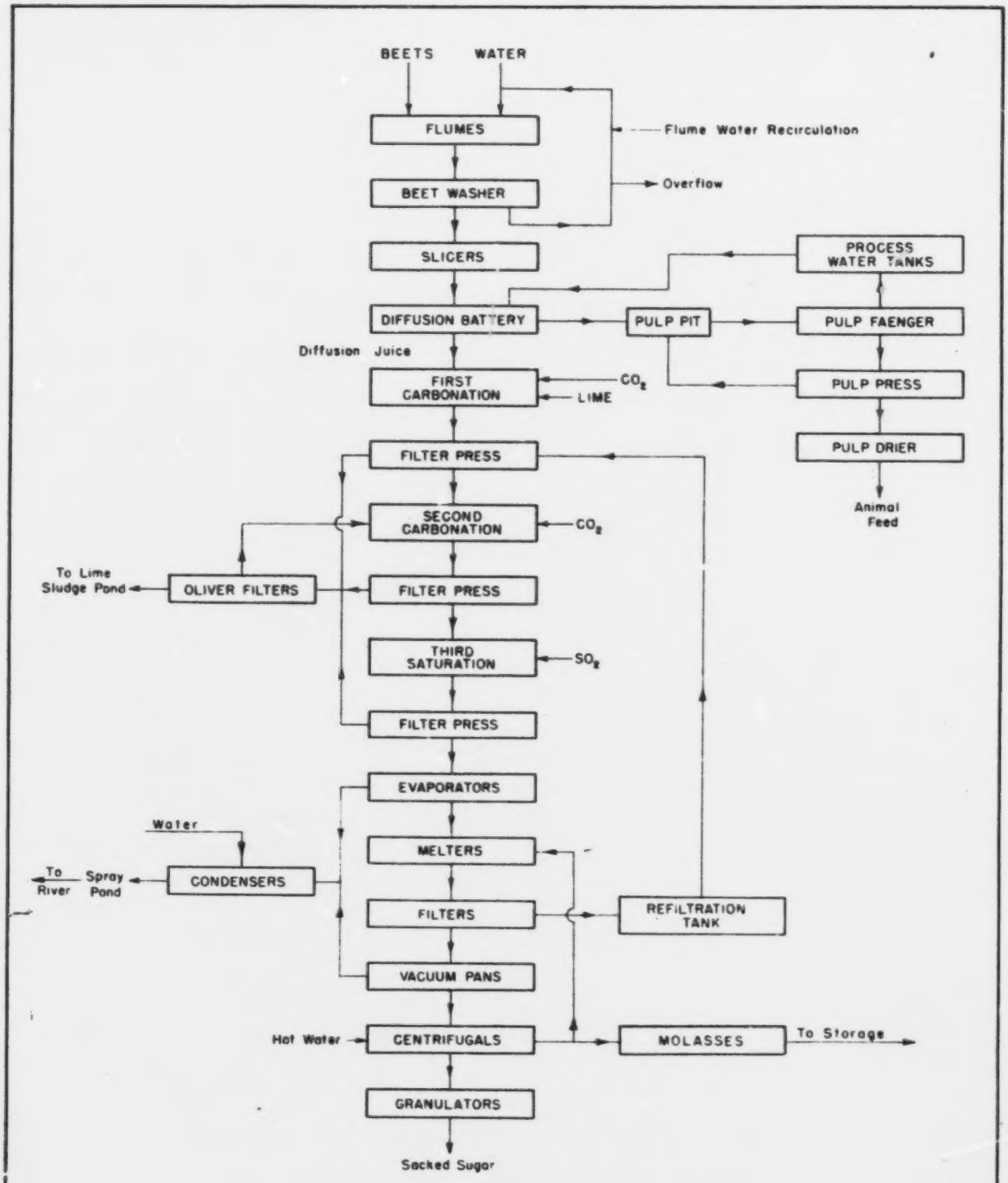

FIGURE 2

FLOW DIAGRAM

BUCKEYE SUGAR COMPANY

OTTAWA, OHIO

FEDERAL SECURITY AGENCY

PUBLIC HEALTH SERVICE

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CINCINNATI, OHIO NOVEMBER, 1949

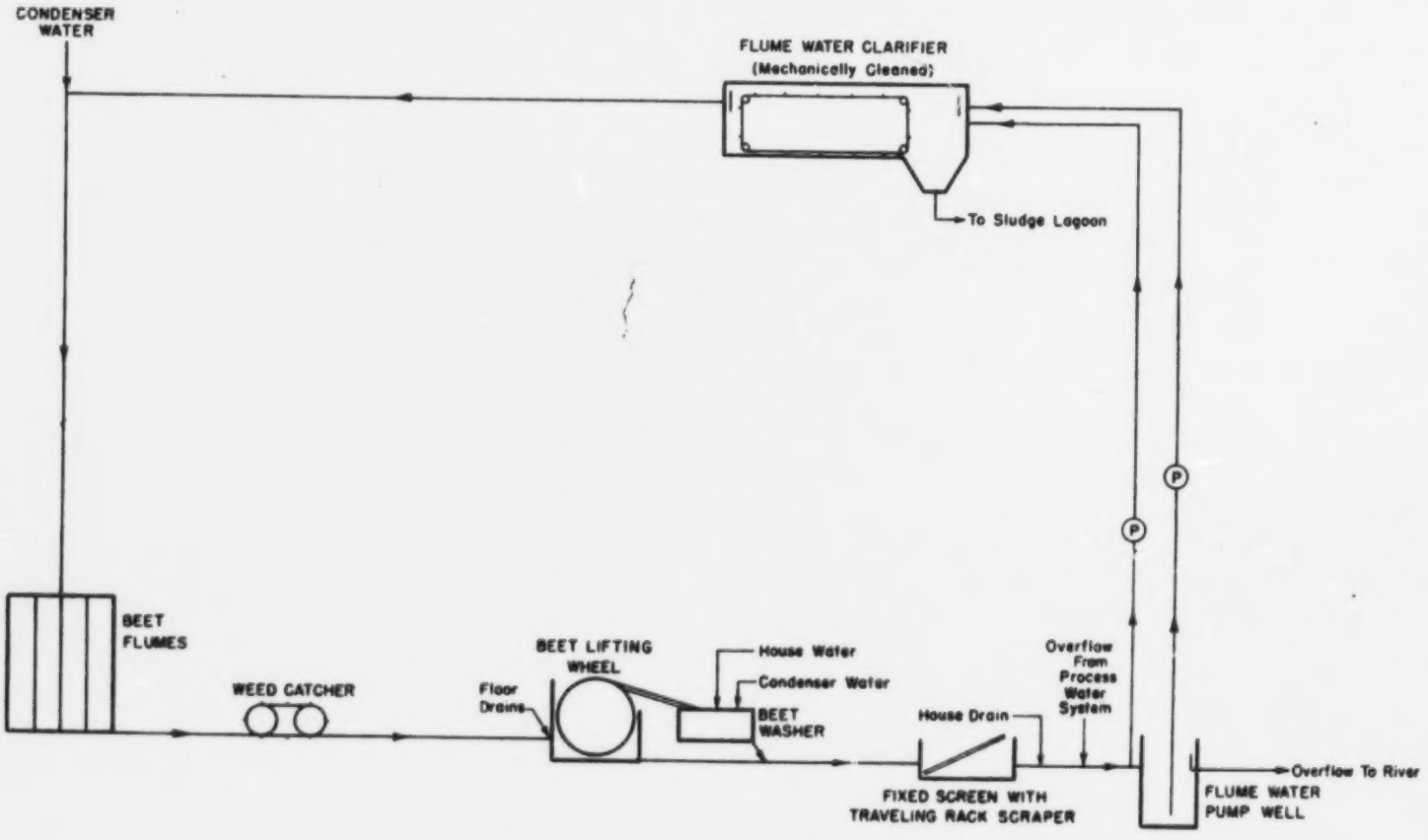

FIGURE 3

FLUME WATER SYSTEM
BUCKEYE SUGAR COMPANY
OTTAWA, OHIO

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as make-up and entered the system from the beet washer and the line carrying the condenser water to the spray pond.

14. Process Water

Process water refers to the water that was used to extract the sugar from the cossettes, battery wash water, and pulp press water. In most sugar factories the latter two components are allowed to flow to the sewer and form one of the most objectionable wastes of the industry. In the plant studied, however, the battery wash water and pulp press water was chlorinated and reused as extraction water. Condenser water was used to make up the volume of process water drawn off as the diffusion juice. Figure 4 is a flow diagram of this closed system. It will be noted that the only loss from the system occurs from the overflow at number three tank. This spill enters the flume water system at a point ahead of the flume water pump well.

15. Barometric Condenser Water

This waste water was obtained from the barometric condensers of the evaporators and vacuum pans. It was the water with the greatest volume but was relatively low in pollutional characteristics. Condensate from the evaporators and entrained vapor were the only possible sources of pollution in the water.

SURVEY METHODS

16. Sample Collection

Table 1 gives a list of the sampling points, the compositing period, the sampling interval, the number of samples, and the amount of sample. Equal portions at shorter time intervals were used in lieu of taking weighted samples.

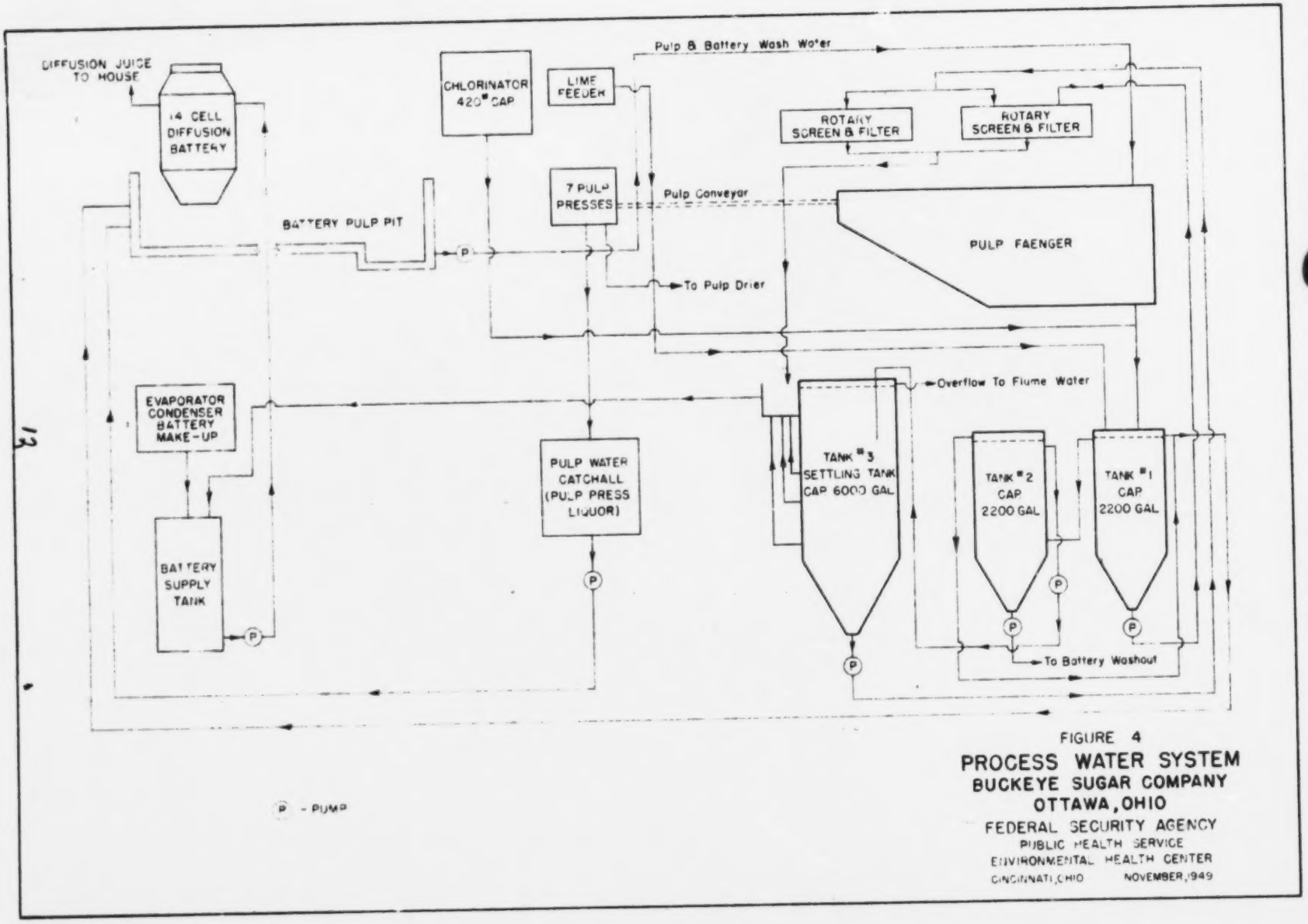

FIGURE 4

PROCESS WATER SYSTEM
BUCKEYE SUGAR COMPANY
OTTAWA, OHIO

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CINCINNATI, OHIO NOVEMBER, 1949

Table 1. Sampling Schedule

Sample	Number of Samples	Compositing Period	Amount of Portion	Sampling Interval
Raw Water Intake	6	24 hr.	16 oz.	1 hr.
Condenser Water Pond Effluent	6	24 hr.	8 oz.	30 min.
Outfall Sewer	6	24 hr.	8 oz.	30 min.
Process Water before Chlorination	6	8 hr.	16 oz.	30 min.
Process Water from Tank #3	6	8 hr.	16 oz.	30 min.
Process Water Filtrate from Rotary Screen	5	8 hr.	16 oz.	30 min.
Lime Slurry from Oliver Filters	4	8 hr.	32 oz.	2 hr.
Flume Water Clarifier Influent	6	8 hr.	8 oz.	30 min.
Flume Water Clarifier Effluent	6	8 hr.	8 oz.	30 min.
Sludge from Flow Water Clarifier	5	8 hr.	16 oz.	1 hr.

Sampling of the raw water intake, condenser water pond effluent, and outfall sewer started at 7:00 A.M. and continued through 6:00 A.M. of the next day. During the first three days of sampling, November 20, 21, 22, the rest of the samples were collected from 11:00 P.M. to 7:00 A.M. while during the last three days, November 25, 26, 27, they were collected from 7:00 A.M. to 3:00 P.M.

Samples of the process water were composited in iced containers, with the exception of November 25 and 26, when this icing was omitted as ice was not available.

17. Flow Measurements

The volume of combined wastes discharged to the river was measured by a 90° V-notch weir installed in a weir box at the end of the sewer outfall. The weir box was constructed of 3/8 inch steel plate and was 9 feet long, 6 feet wide and 3.5 feet deep. The notch of the weir was located 1.5 feet from the bottom

of the box. Two baffles were placed in the box, one at each of the third points. The baffle nearest to the inlet of the box was an underwater baffle rising 18 inches from the bottom of the box, while the one closer to the notch extended 18 inches below the water surface. A Friez Water Stage Recorder was used to maintain a continuous record of weir head readings on a 24-hour basis. The stilling well for the recorder was placed just behind the baffle nearest to the notch. Flow over the weir was computed by the formula:

$$Q = 2.52\ H^{2.47}$$

where Q = Discharge in C.F.S.

H = Head in feet

Measurements of overflow from the flume water system to the outfall sewer were made in the flume water pump well. A Friez Water Stage Recorder was used to maintain a continuous record of the head over a 2.5 foot rectangular weir with end contractions. Due to the formation of foam and accumulation of debris in the pump well the float of the recorder was buoyed up above the actual water level and therefore measurements of this flow are not considered reliable.

The volume of water withdrawn from the flume water system to the sludge lagoon was calculated from the capacity of the sludge pump. The capacity of the pump was determined by drawing down the water level in the clarifier, a measured amount in an observed time interval.

18. Laboratory Procedure

The following determinations were made on the samples collected:

pH
Alkalinity
Biochemical Oxygen Demand (5-Day 20°C)
Total Solids - Total and Volatile
Suspended Solids - Total and Volatile

Chlorine Demand
Total Sulfur
Ammonia Nitrogen
Organic Nitrogen
Turbidity

In general the procedures followed in making the above analyses were as given in "Standard Methods for the Examination of Water and Sewage," 9th Edition.[1] Modifications were made in the procedures for analysis of chlorine demand and total sulfur. The modified procedures are given in Appendix B.

EXPLANATION OF ANALYSES

A brief explanation of the various laboratory determinations is given below as an aid to the industry in the interpretation of the analytical results reported.

19. pH

The symbol "pH" denotes the logarithm of the reciprocal of the hydrogen-ion concentration, this symbol being a universal one in chemistry. The pH value indicates the relative acidity or alkalinity of a water or waste, being lower with higher degrees of acidity. It is a measure of intensity rather than quantity.

20. Alkalinity

Alkalinity of a water or waste represents its content of carbonates, bicarbonates, hydroxides, and very occasionally borates, silicates and phosphates of the alkali and alkali earth metals. Calcium and magnesium are the two metals which account for most of the alkalinity. The results for alkalinity are expressed as parts per million of calcium carbonate ($CaCO_3$).

21. Biochemical Oxygen Demand

The biochemical oxygen demand (B.O.D.) of sewage, polluted waters, or industrial wastes, is the oxygen required during stabilization of the decomposable

organic matter by aerobic bacterial action. The time and temperature values most generally used for this test are 5 days and 20°C., respectively. For domestic sewage approximately 68% of the first stage demand is satisfied in 5 days.[2] Because of the variable carbon-nitrogen ratio of some industrial wastes, however, the rate of oxygen demand of such wastes may not follow the typical oxidation curve for domestic sewage.

In sugar beet wastes the ultimate B.O.D. of sucrose may be calculated on the assumption that it will be oxidized to water and carbon dioxide according to the equation:

$$C_{12} H_{22} O_{11} + 12 O_2 \rightarrow 11 H_2O + 12 CO_2$$

indicating that 1 ppm of sucrose has an ultimate B.O.D. (L) of 1.12 ppm. Assuming that 68.3 per cent of the (L) value is oxidized in 5 days, 1 ppm of sucrose has a 5 day B.O.D. of 0.765 ppm.

22. Population Equivalent

Normal domestic sewage, relatively free from industrial wastes, possesses characteristics which are reasonably well defined and it is therefore possible to compare them on a common basis. Industrial wastes are influenced by the process from which they originate and the characteristics are not readily defined by the same standards. The "Population Equivalent" value, therefore provides a basis on which industrial wastes may be compared to domestic sewage. The coefficient of 0.167 pounds of 5 day 20°C. B.O.D. per capita per day, used in comparing domestic sewages, has been used in converting these data to a population equivalent basis.[2]

23. Chlorine Demand

The chlorine demand represents the amount of chlorine which must be added to a water or waste to produce a trace (0.1 ppm) of residual chlorine

after a given contact time. In this study a 15 minute contact time was used. Determinations were made at 20° C which is the standard temperature and at 50° C to compare the demand with the actual temperature used in the process. The test is an indicator of the amount of organic matter present in the waste, the chlorine demand increasing, in general, with an increase in the organic material.

24. Total Sulfur

Under anaerobic conditions sulfur may be converted to sulfides, principally hydrogen sulfide. These sulfides may cause a nuisance due to odor and corrosion.

25. Ammonia Nitrogen

The presence of a small quantity of ammonia nitrogen in a waste may be an indication of the freshness of the waste and marks the first step in the process of decomposition. In the sugar beet wastes the constant presence of ammonia in chlorine-treated solutions would indicate that chloramines are the operative disinfecting agent.

26. Organic Nitrogen

One measure of the strength or concentration of a waste may be determined by means of the test for organic nitrogen. The presence of large amounts of organic nitrogen shows the presence of proteins, their decomposition products, amino acids, or compounds of a similar nature. It is reported by Marks,[3] that in the presence of such materials chlorine may react to form compounds having disinfecting properties which do not indicate their presence by orthotolidine or starch-iodide. It is possible that control based on the use of Marks amperometric titration might have permitted lower chlorine doses in the process water as it might show that more effective residual chlorine than

is indicated by the orthotolidine test is being carried through the treatment unit.

27. Turbidity

Turbidity is an expression of an optical approximation of the suspended matter, based on the similarity of interference to the passage of light rays through a sample when compared with standard samples of recorded turbidity.

DISCUSSION OF RESULTS

28. Flume Water System and Outfall Sewer

This survey was conducted during the last week of operations at the plant and as a result flows in the waste water systems were not normal. The results therefore, should be examined with this condition in mind, especially in regard to the data on the flume water system and outfall sewer.

Figure 3 is a line diagram of the Flume Water System. This is virtually a closed system and no water normally should leave it during the entire campaign except through the flume water clarifier sludge pump. At the end of the campaign the valve in the flume water receiving well is opened and the water is discharged to the river.

Occasionally, however, beets pile up in the flumes and form a dam which creates a large pool behind the piled beets. When the beets are dislodged the pooled water enters the flume water pump well in large surges and spills over the weir to the outfall sewer. Company officials have expressed their intention to build a new and larger receiving well and install an additional pump with capacity adequate to prevent overflow of the flume water into the outfall sewer. The installation of this facility should render the flume water system a completely closed circuit.

During the period of this survey, variable overflow from the flume water system occurred at frequent intervals. This was caused by the fact that

cleaning of the silt deposited in the flumes had begun and water in excess of that required for normal fluming was diverted into the system. This cleaning water was taken from the condenser water system before it entered the condenser water spray pond. The estimated volume of flume water that overflowed from the system to the outfall sewer varied from 0.15 to 0.37 m.g.d. and amounted to 5-13 percent of the total flow in the outfall sewer. This wasted flume water accounted for the greatest portion of the pollution load leaving the plant as indicated in Table 2.

Table 2. Contribution of Flume Water to Outfall Sewer

Date	Outfall Sewer Discharge (MGD)	Flume Water Overflow MGD *	Flume Water Overflow % Total Outfall Sewer Flow	% Total Load Contributed to River by Flume Water B.O.D.	Suspended Solids	Total Solids
11/20/49	2.75	0.25	9	75	97	98
11/21/49	2.97	0.15	5	71	88	100
11/25/49	2.89	0.24	8	82	94	100
11/26/49	2.90	0.37	13	87	95	97

* Calculated on basis of solids and B.O.D. results

The concentration of the polluting substances in the flume water was probably higher than usual due to the flushing out of the flumes. Organic material that had been deposited with the silt in the flumes during the campaign, was placed in suspension again during this period.

Sludge from the clarification tank in the flume water system was withdrawn continually and pumped to a lagoon. The sludge was pumped at a rate of 150 gallons per minute and contained an average of 1.5 percent dry solids. The efficiency of the clarifier based on suspended solids removal was 48 percent.

With the elimination of flume water from the outfall sewer, the waste

water discharged to the river would be made up primarily of cooled condenser (cooling) water and a small amount of sanitary sewage. Condenser water is cooled in a spray pond to reduce the temperature and thereby reduce its effect on the river.

Analyses of the raw water supply from the river and of the condenser water at the overflow from the spray pond showed a definite increase in the B.O.D. of the condenser water as it passed through the plant. The B.O.D. results of the river water ranged from 18 to 47 ppm while those of the condenser water ranged from 46 to 96 ppm. The increase in the pollution load resulting from the discharge of condenser water with an average increase of 36 ppm of B.O.D. represents a population equivalent of 4.8 per ton of beets sliced. Tables 3 and 4 show the B.O.D. load and population equivalent per ton of beets sliced for the outfall sewer and the condenser water.

There was also a slight increase in suspended solids but relatively no change in total solids between the river water influent and the condenser water as it is discharged to the outfall sewer.

Table 3. Summary of B.O.D. Data and Population Equivalents for Outfall Sewer
Buckeye Sugar Company, Ottawa, Ohio

Date	Tons of Beets Sliced	Outfall Sewer Flow M.G.D.	Raw Water B.O.D.		Outfall Sewer B. O. D.				
			5-day 20°C PPM	Lbs./ Day	5 Day 20° C PPM	Lbs./ Day	Net lbs. added to river/ Day	Lbs./ Tons of Beets	Pop. Equiv. Ton of Beets
11/20/49	977	2.75	18.4	420	121	2775	2355	2.4	14
11/21/49	1010	2.97	27.3	680	142	3520	2840	2.8	16
11/25/49	975	2.89	41	990	219	5260	4290	4.4	26
11/26/49	1002	2.90	47	1140	364	8800	7660	7.6	45
Average	991	2.88	33.4	810	212	5095	4285	4.3	25

Table 4. Summary of B.O.D. Data and Population Equivalents for Condenser Water
Buckeye Sugar Company, Ottawa, Ohio

Date	Tons of Beets Sliced	Esti-mated Flow M.G.D.	Raw Water B.O.D.		Condenser Water B.O.D.				
			5-day 20°C PPM	Lbs./ Day	5 Day 20° C PPM	Lbs./ Day	Net lbs. added to river/ Day	Lbs./ Tons of Beets	Pop. Equiv Ton of Beets
11/20/49	977	2.50	18.4	420	46	960	580	0.59	3.5
11/21/49	1010	2.82	27.3	680	62	1460	820	0.81	4.8
11/25/49	975	2.65	41	990	76	1680	775	0.79	4.7
11/26/49	1002	2.53	47	1140	96	2025	1035	1.03	6.1
Average	991	2.62	33.4	810	70	1530	800	0.81	4.8

29. Lime Waste

Milk of lime is added to the first carbonation tank and precipitated as calcium carbonate by the addition of carbon dixode. The precipitated calcium carbonate is removed from the diffusion juice by filter presses. The precipitate from the filter presses is then washed, to remove the last trace of sugar, and filtered on Oliver filters. The cake produced on the Oliver filters is diluted to a slurry and pumped to a lagoon for disposal.

It was estimated that 20 tons of lime were used daily at the plant. Analysis of the lime waste showed it had an average 5 day B.O.D. of 10,200 p.p.m.

30. Process Water System

The process water system at this plant is designed as a closed circuit in which diffusion battery wash water and pulp press water is treated and reused as diffusion battery water. The treatment process consists of chlorination, addition of lime for pH control, and sedimentation. The three tanks used in the treatment process had a combined capacity of 10,400 gallons and provided a detention period of approximately 35 minutes with an estimated daily recirculated flow of 420,000 gallons. Chlorine was added to the process water in the influent line to the first tank and lime was added directly to the same tank. Plant records show a gradual increase in chlorine requirements of the water from the start of the campaign to the time of the survey when the average rate of chlorine dosage was 350 pounds per 24 hours or 100 p.p.m. The rate of chlorine dosage was adjusted to maintain a trace residual in the effluent from the last tank in the treatment unit.

The chlorine dosage used during the greater portion of the past

campaign was in excess of requirements estimated by Dr.Pearson. Experiments by Dr.Pearson indicated that chlorine contact time of ten minutes was sufficient to kill thermophilic bacteria and thus retard fermentation. Chlorine residual tests by plant personnel, however, were made after a contact period of approximately 35 minutes and the results were used to adjust the rate of chlorine dosage to the system.

Laboratory tests show the process water had an average chlorine demand at 20°C and 15 minute contact period of 68 p.p.m. The average chlorine demand after a 15 minute contact period at 50°C, corresponding to the temperature in the process water system, was 73 p.p.m.

A summary of data available from various sources on chlorine dose or demand, residuals at various times and per cent kill of thermophiles follows:

	1949 Laboratory Results	1949 Operation	Dr.Pearson Thesis (1)
Chlorine Dose or Demand p.p.m.	60 to 82	100	3.0
Time - Minutes	15	35	10
Temperature, °C	50	50	Not stated
Residual	0.1	Trace	1.0 to 2.0

(1) Pure culture experiments - 99 to 100 per cent kill of thermophiles reported.

Company records show that the total solids in the recirculated process water increased gradually during the first two weeks and remained at a high level for the rest of the campaign. During this study the total solids entering the first tank of the treatment unit averaged 9130 p.p.m. while the total solids in the effluent from the final tank averaged 8750 p.p.m. This represents a reduction in the total solids of 4.2 per cent. The tests for suspended solids in the corresponding samples showed an average concentration of 3250 p.p.m. and 2860 p.p.m. which is a reduction of 12.4 per cent.

Organic nitrogen, which is a measure of protein material, also showed a reduction of 12.4 per cent and was decreased from 155 to 138 p.p.m. The B.O.D. was reduced 8 per cent, being decreased from 5250 to 4830 p.p.m.

The pH of the process water influent to the treatment unit before chlorination varied from slightly alkaline to acid, ranging from 7.7 to 4.6. On two days (November 25, 26) the samples were not iced during collection, and the low pH values may be due, in part, to fermentation having occurred during the sampling period. No similar explanation can be given for the low pH value on the iced sample collected on the last day of the study. The pH of the sample on that day was 4.6.

The pH of the process water in the treatment unit was adjusted by the addition of milk of lime into the first tank of the unit. The pH values of the effluent from the final tank were all on the alkaline side with one exception, when it was neutral. The values ranged from 7.0 to 7.6.

Company officials reported a gradual buildup of sugar content in the process water during the first month of the campaign. The amount of sugar extracted from the beets with the recirculated process water is comparable to the amount extracted previously with the use of new or fresh water in the diffusion battery. The yield of sugar in the sack was slightly lower than in previous campaigns being 81.79 per cent on beets with a sugar content of 15.43 per cent. The amount of sugar in the molasses was slightly higher and the loss of sugar in pulp and pulp water was lower than in previous campaigns.

The above values indicate that use of recirculated process water containing high solids and sugar in solution has no significant effect upon the sugar yield.

From the standpoint of pollution abatement, it is evident that inauguration of closed systems, for flume water and process water, holds great possi-

bilities in that population equivalent can be reduced to less than five persons per ton of boots sliced.

Acknowledgement

It is desired to express appreciation to Mr. Ralph Dush and Mr. George Fleming, of the Buckeye Sugar Company, and the personnel under their direction, for the cooperation and assistance extended during the conduct of this survey.

Irwin P. Sandor
Assistant Sanitary Engineer

Paul Agnano
Sanitary Engineer (R)

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2. Theriault, Emory J., "The Oxygen Demand of Polluted Waters." Public Health Bulletin No. 173, U. S. Government Printing Office, 1927, p.44-54.

3. Marks, H. C., and Goines, R. R., "Determination of Residual Chlorine in Sewage." Analytical Chemistry, Vol. 20, 12 p.1197 (1948).

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Table 5 - Summary of Analytical Data - Raw Wate

Industry - Buckeye Sugar Company Location - Ottawa, O

Source of Sample	Date	Flow M.G.D.	Total Solids		Suspended Solids		B 5-d
			Total ppm	Volatile ppm	Total ppm	Volatile ppm	p
Raw Water Intake - Blanchard River	11/20-21/49	3.38	760	242	23	12	1
	11/21-22/49	3.61	880	224	20	10	2
	11/22-23/49	3.51	828	312	66	42	>3
	11/25-26/49	3.52	916	294	35	26	4
	11/26-27/49	3.53	806	256	40	28	4
	11/27/49	-	768	276	44	32	4
Average		3.51	825	267	38	25	3
Condenser Water	11/20-21/49	-	766	338	30	17	4
	11/21-22/49	-	840	298	34	16	6
	11/22-23/49	-	1010	478	51	35	6
	11/25-26/49	-	854	302	53	40	7
	11/26-27/49	-	828	292	62	40	9
	11/27/49	-	826	298	57	38	10
Average			854	334	48	31	7
Outfall Sewer	11/20-21/49	2.75	1040	398	200	65	12
	11/21-22/49	2.97	1010	376	134	43	14
	11/22-23/49	2.88	1160	466	272	120	21
	11/25-26/49	2.89	1240	486	320	124	21
	11/26-27/49	2.90	1430	568	444	160	36
	11/27/49	-	1360	500	520	170	22
Average		2.88	1210	466	315	115	21

* Not included in average

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Table 5 - Summary of Analytical Data - Raw Water Intake, Condenser Water, Outfall Sewer

ckeye Sugar Company Location - Ottawa, Ohio Receiving Stream -

	Flow M.G.D.	Total Solids		Suspended Solids		B.O.D. 5-day-20°C	Nitrogen		pH	Alkalinity	Ch
		Total ppm	Volatile ppm	Total ppm	Volatile ppm	ppm	Ammonia ppm	Organic ppm		ppm	
/49	3.38	760	242	23	12	18.4	0.20	-	8.3	328	
/49	3.61	880	224	20	10	27.3	0.05	-	7.9	376	
/49	3.51	828	312	66	42	>30.8*	0.25	-	8.2	318	
/49	3.52	916	294	35	26	41	0.55	-	8.3	369	
/49	3.53	806	256	40	28	47	0.10	-	7.9	346	
	-	768	276	44	32	44	0.10	-	8.1	316	
	3.51	825	267	38	25	35.5	0.21	-	8.1	342	
/49	-	766	338	30	17	46	-	-	7.7	333	
/49	-	840	298	34	16	62	-	-	7.7	312	
/49	-	1010	478	51	35	64	-	-	7.3	339	
/49	-	854	302	53	40	76	-	-	8.1	350	
/49	-	828	292	62	40	96	-	-	8.0	329	
	-	826	298	57	38	103	-	-	8.1	349	
		854	334	48	31	75	-	-	7.8	335	
/49	2.75	1040	398	200	65	121	0.55	6.30	7.3	294	
/49	2.97	1010	376	134	43	142	0.20	-	7.4	271	
/49	2.88	1160	466	272	120	211	0.20	10.60	7.1	308	
/49	2.89	1240	486	320	124	219	0.70	5.30	7.3	337	
/49	2.90	1430	568	444	160	364	0.20	14.50	7.3	233	
	-	1360	500	520	170	220	0.45	19.40	7.7	301	
	2.88	1210	466	315	115	213	0.38	11.20	7.4	291	

* included in average

Appendix A

Federal Security Agency
Public Health Service
Environmental Health Center

Raw Water Intake, Condenser Water, Outfall Sewer

ttawa, Ohio

Receiving Stream - Blanchard River

ids le	B.O.D. 5-day-20° C ppm	Nitrogen Ammonia ppm	Nitrogen Organic ppm	pH	Alkalinity ppm	Chlorine Demand 15 min. ppm	Total Sulfur ppm	Turbidity ppm
	18.4	0.20	-	8.3	328	4.87	-	<25*
	27.3	0.05	-	7.9	376	4.21	-	-
	>30.8*	0.25	-	8.2	318	4.43	58	31
	41	0.55	-	8.3	369	2.13	72	39
	47	0.10	-	7.9	346	4.43	62	55
	44	0.10	-	8.1	316	3.54	54	49
	35.5	0.21	-	8.1	342	3.93	61	43
	46	-	-	7.7	333	4.78	-	37
	62	-	-	7.7	312	4.25	60	56
	64	-	-	7.3	339	5.14	59	58
	76	-	-	8.1	350	5.32	-	65
	96	-	-	8.0	329	5.85	-	80
	103	-	-	8.1	349	4.96	60	86
	75	-	-	7.8	335	5.22	60	64
	121	0.55	6.30	7.3	294	7.80	64	157
	142	0.20	-	7.4	271	7.10	62	154
	211	0.20	10.60	7.1	308	8.51	59	227
	219	0.70	5.30	7.3	337	5.14	61	320
	364	0.20	14.50	7.3	233	10.00	60	548
	220	0.45	19.40	7.7	301	9.39	61	560
	213	0.38	11.20	7.4	291	7.99	61	328

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Table 6 - Summary of Analyt

Industry - Buckeye Sugar Company Location - Ott

Source of Sample	Date	Total Solids		Suspended Solids		B.O.D. 5-day-20
		Total ppm	Volatile ppm	Total ppm	Volatile ppm	ppm
Flume Water - Influent to Clarifier	11/20-21/49	3820	1820	2070	532	1170
	11/21-22/49	4650	2220	1980	460	1510
	11/22-23/49	5230	2160	2760	570	1610
	11/25/49	6020	2270	4600	900	1500
	11/26/49	4850	1780	3540	1020	1160
	11/27/49	5780	1650	4680	900	969
Average		5060	2040	3170	730	1320
Flume Water - Effluent from Clarifier	11/20-21/49	3090	1660	1160	328	1130
	11/21-22/49	3730	2080	1320	372	1540
	11/22-23/49	3680	2020	1470	460	1290
	11/25/49	4150	2020	2000	790	1490
	11/26/49	3640	1540	1930	560	1100
	11/27/49	3060	1420	1400	460	986
Average		3560	1790	1550	495	1260
Sludge from Flume Water Clarifier	11/20-21/49	10700	3600	8860	2220	
	11/22-23/49	8530	3030	5840	1460	
	11/25/49	20800	5510	14700	4200	
	11/27/49	23200	4620	18900	3980	
Average		15800	4190	12100	2470	

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Appendi

Table 6 - Summary of Analytical Data Plume Water System

any Location - Ottawa, Ohio Receiving Stream - Blanchard R

olids olatile ppm	Suspended Solids Total ppm	Suspended Solids Volatile ppm	B.O.D. 5-day-20°C ppm	Nitrogen Ammonia ppm	Nitrogen Organic ppm	pH	Total Alkalinity ppm	Chlorine Demand 15 min. ppm	Total Sulfur ppm
1820	2070	532	1170	0.30	13.70	5.9	68	83	-
2220	1980	460	1510	0.50	34.20	6.5	174	82	-
2460	2760	570	1610	0.50	46.80	6.5	82	73	61
2270	4[illegible]	9[illegible]	1500	0.60	43.80	6.9	441	67	64
1780	3540	1020	1160	0.25	35.80	6.1	155	85	-
1650	4680	900	969	0.25	18.80	6.8	220	83	-
2040	3170	730	1320	0.40	32.80	6.5	190	79	63
1660	1160	328	1130	0.50	13.30	6.4	258	67	-
2080	1320	372	1540	0.55	22.60	6.9	93	72	-
2020	2470	460	1290	0.40	29.50	6.9	80	73	60
2020	2000	790	1490	0.55	30.50	6.9	410	71	60
1540	1950	560	1100	0.25	29.00	6.2	155	76	66
1420	1400	460	986	0.25	14.90	6.9	223	64	-
1790	1550	495	1260	0.41	23.30	6.7	199	71	62
3600	8860	2220							
3030	5840	1460							
3[illegible]10	14700	4200							
4620	18900	7980							
4190	12100	2470							

B

C

tical Data Plume Water System

Appendix A

Federal Security Agency
Public Health Service
Environmental Health Center

tawa, Ohio

Receiving Stream - Blanchard River

°C	Nitrogen		pH	Total Alkalinity ppm	Chlorine Demand 15 min. ppm	Total Sulfur ppm	Turbidity ppm
	Ammonia ppm	Organic ppm					
	0.30	13.70	5.9	68	85	-	-
	0.50	34.20	6.5	174	82	-	-
	0.50	46.80	6.5	82	73	61	3000
	0.60	43.80	6.9	441	67	64	3220
	0.25	35.80	6.2	155	85	-	3280
	0.25	18.80	6.8	220	83	-	3700
	0.40	32.80	6.5	190	79	63	3300
	0.50	13.30	6.4	238	67	-	-
	0.55	22.60	6.9	93	72	-	-
	0.40	29.50	6.9	80	73	60	1800
	0.55	30.50	6.9	410	71	60	2380
	0.25	29.00	6.2	155	76	66	2420
	0.25	14.90	6.9	223	64	-	1740
	0.41	23.30	6.7	199	71	62	2090

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Table 7 - Summary of Analytical Data -

Industry - Buckeye Sugar Company Location - Ottawa,

Source of Sample	Date	Total Solids		Suspended Solids		B.O.D. 5-day-20C	Amm
		Total ppm	Volatile ppm	Total ppm	Volatile ppm	ppm	p
Process Water Tank #1 Influent	11/20-21/49	9960	8620	3220	2620	5420	21
	11/21-22/49	11600	10100	3660	2760	6880	15
	11/22-23/49	8780	7630	2660	2220	4800	17
	* 11/25/49	8830	7410	3540	2840	4970	10
	* 11/26/49	8240	6940	3180	2620	5000	2
	11/27/49	7400	6270	3220	2540	4410	7
Average		9130	7830	3250	2600	5250	12
Process Water Tank #3 Effluent	11/20-21/49	9200	7980	3260	2620	5100	20
	11/21-22/49	10700	9480	3760	2820	6180	17
	11/22-23/49	8500	7370	2440	2040	4520	19
	* 11/25/49	8390	7000	2840	2180	4680	15
	* 11/26/49	8070	6800	2540	2040	4300	13
	11/27/49	7570	6430	2340	1860	4220	19
Average		8750	7510	2860	2260	4830	17
Process Water Filtrate from Rotary Screen	11/20-21/49	8720	7460	2810	2200	5160	38
	11/22-23/49	7900	6860	2020	1740	4020	21
	* 11/25/49	7920	6630	2460	1880	4700	15
	* 11/26/49	7820	6540	2380	1900	4320	14
	11/27/49	7380	6320	2140	1640	4090	20
Average		7950	6760	2360	1870	4460	22

* Samples not iced

B

Summary of Analytical Data - Process Water System

Location - Ottawa, Ohio

Receiving Stream - Blanchard River

Suspended Solids Total ppm	Suspended Solids Volatile ppm	B.O.D. 5-day-20°C ppm	Nitrogen Ammonia ppm	Nitrogen Organic ppm	pH	Total Alkalinity ppm	Chlorine Demand 15 min. ppm 20°C	Chlorine Demand 15 min. ppm 50°C	Chlorine Residual ppm	Total Sulfur ppm	Temp °C
220	2620	5420	21.10	131	6.8	207	60	71	-	59	49
660	2760	6880	15.60	185	7.3	103	57	64	-	-	48
660	2220	4800	17.60	130	7.7	235	39	60	-	-	47
540	2840	4970	10.20	153	5.1	171	78	78	-	-	49
180	2620	5000	2.80	163	4.5	45	82	82	-	-	48
220	2540	4410	7.50	165	4.6	53	89	82	-	-	46
250	2600	5250	12.50	155	6.0	136	68	73	-	-	48
260	2420	5100	20.2	119	7.0	176	0	-	-	56	49
760	2820	6180	17.7	173	7.4	120	-	-	Trace	45	48
440	2040	4520	19.6	123	7.6	214	-	-	Trace	-	47
840	2180	4680	15.6	145	7.3	255	1.51	-	-	-	49
540	2040	4300	13.8	140	7.4	227	-	-	Trace	-	48
840	1860	4220	19.2	129	7.4	240	-	-	Trace	-	47
860	2260	4830	17.7	138	7.4	205	-	-	-		48
810	2200	5160	38.0	117	7.1	177	0.80	-	-		
020	1740	4020	21.6	101	7.7	197	-	-	Trace		
460	1880	4700	15.6	145	7.5	267	0	-	-		
380	1900	4320	14.8	146	7.7	234	-	-	Trace		
140	1640	4090	20.1	125	7.5	253	-	-	Trace		
360	1870	4460	22.0	127	7.5	226	-	-	-		

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B

Appendix A

C

Process Water System

Federal Security Agency
Public Health Service
Environmental Health Center

Ohio

Receiving Stream - Blanchard River

Nitrogen				Chlorine Demand 15 min. ppm				
monia ppm	Organic ppm	pH	Total Alkalinity ppm	20°C	50°C	Chlorine Residual ppm	Total Sulfur ppm	Temp. °C
.10	131	6.8	207	60	71	-	59	49
.60	185	7.3	103	57	64	-	-	48
60	130	7.7	235	39	60	-	-	47
.20	153	5.1	171	78	78	-	-	49
.80	163	4.5	45	82	82	-	-	48
.50	165	4.6	53	89	82	-	-	46
.50	155	6.0	136	68	73	-	-	48
.2	119	7.0	176	0	-	-	56	49
.7	173	7.4	120	-	-	Trace	45	48
.6	123	7.6	214	-	-	Trace	-	47
.6	145	7.3	255	1.51	-	-	-	49
.8	140	7.4	227	-	-	Trace	-	48
.2	129	7.4	240	-	-	Trace	-	47
.7	138	7.4	205	-	-	-		48
.0	117	7.1	177	0.80	-	-		
.6	101	7.7	197	-	-	Trace		
.6	145	7.5	267	0	-	-		
.8	146	7.7	234	-	-	Trace		
.1	125	7.5	253	-	-	Trace		
.0	127	7.5	226	-	-	-		

Table 8 - Summary of Analytical Data

Lime Waste

Industry - Buckeye Sugar Company Location - Ottawa, Ohio

Source of Sample	Date	Total Solids		Suspended Solids		BOD 5-day-20° ppm	Total Sulfur ppm	Organic Nitrogen ppm
		Total ppm	Volatile ppm	Total ppm	Volatile ppm			
Lime Cake	11/20-21/49	253,000	37,900	250,000	36,300	10,800	76	572
	11/21-22/49	209,000	31,200	202,000	28,200	10,600	--	607
	11/25/49	164,000	72,400	155,000	24,000	8,860	276	442
	11/26/49	175,000	35,500	170,000	23,000	11,700	323	585
	Average	200,000	44,300	194,000	27,900	10,200	225	541

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APPENDIX B

Laboratory Procedure for Determination of Sulfur

Reagents

Bromine

Hydrochloric acid

Procedure

1. To a neutral (or slightly alkaline) portion of sample add bromine until an excess is present. If alkaline, the excess bromine is determined by acidifying a few drops to liberate bromine.
2. Let stand 2-4 hours or over night.
3. Boil for several minutes, make barely acid with HCl, and reboil to remove the excess bromine.
4. Determine total sulfur by gravimetric method as given in Standard Methods (9th Edition, p. 83-4).

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APPENDIX C

Laboratory Procedure for Determination of Chlorine Demand

Reagents

Chlorine solution - approximately 0.5 mg/ml.

N/40 sodium thiosulfate

Potassium Iodide C. P.

Acetic Acid C. P.

Starch solution indicator

Procedure

1. Standardize chlorine solution according to Standard Methods (9th Edition) p. 148.
2. Add 1, 2, 5, etc., milliliter portions of the standard chlorine solution to suitable portions (or dilutions) of the sample at 2 or 3 minute intervals. Chlorine dosage is staggered so that each individual titration can be made exactly 15 minutes after such dosage.
3. Immediately before titrating, acidify sample with acetic acid. This is necessary to obtain complete recovery of residual chlorine.
4. Determine chlorine demand as in Standard Methods, 9th Edition.